

REMARKS/ARGUMENTS

Reexamination and reconsideration of this Application, withdrawal of the rejection, and formal notification of the allowability of all claims as now presented are earnestly solicited.

Applicants confirm election of Claims 1-22, which the Examiner has designated as Group I. Thus, Claims 23-26 have been withdrawn from consideration. Applicants also confirm the election of species recited in the Office Action; namely, election of aromatic polyester for Claim 5, polyalkylene terephthalate for Claim 6, PET for Claim 7, and polyester for Claim 1. Accordingly, Claims 9-11 are currently withdrawn as being directed to a non-elected invention. However, Applicants respectfully request consideration of additional species, including those species set forth in Claims 9-11, upon allowance of a generic claim as provided by 37 C.F.R. §1.141.

Applicants traverse the restriction requirement on the ground that search and examination of all claims can be conducted without serious burden to the Examiner. Since all claims include a reference to a multicomponent fiber, or a process for making such a fiber, that includes a polyarylene sulfide polymer component and a second dissimilar component, Applicants respectfully submit that all claims could be examined without serious burden to the Examiner. As set forth in MPEP §803, under such circumstances, restriction is improper.

Claims 1-29 are pending in the application. Applicants have amended Claims 1, 12, 14, and 20-22. It is respectfully submitted that all claim amendments are supported by the specification as filed. In particular, Applicants note that the reference to the second component being free of liquid crystalline polymer in amended Claim 1 is supported throughout the specification, and particularly on page 10 (paragraph 48). As noted therein, the term "isotropic semi-crystalline" is defined as excluding liquid crystalline polymers. Claims 12 and 14 have been amended to clarify the structure of the core and island components of the fiber by incorporating language from Claim 1. This is viewed as a non-limiting amendment and is not offered in response to any claim rejection of record. Claims 20-22 have been amended in a non-limiting manner to correct a minor informality with respect to the lack of antecedent basis pointed out in the Office Action. The reference to "fiber-forming component" in Claims 20-22 has been corrected to refer to the "second component", which has clear antecedent basis in Claim

1. This change is clearly supported in the specification, such as on pages 11 and 12 (paragraphs 50-53), wherein the component that is free of polyarylene sulfide polymer is consistently referred to as a fiber-forming component. Claim 21 has also been amended to correct the inadvertent omission of a comma after "Claim 20." New Claims 27-29 have been added. The new claims depend from Claim 12 and include subject matter of other claims of record. Entry of these amendments is respectfully requested.

Claims 20-22 stand rejected under 35 U.S.C. §112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which Applicants regard as the invention. Specifically, the Examiner objects to the term "fiber-forming component" as lacking proper antecedent basis. As noted above, Applicants have corrected this informality and, as a result, respectfully request reconsideration and withdrawal of this rejection.

Claims 1-8 and 12-19 stand rejected under 35 U.S.C. 102(b) as being clearly anticipated by JP 6-123013. Relying on the abstract of the Japanese reference, the Examiner alleges that the reference teaches a multicomponent sheath/core fiber that may include an anisotropic aromatic polyester core and a polyarylene sulfide sheath. The Examiner alleges that PET is a possible core material for use in the fiber taught in the Japanese reference. In addition, the Examiner requires that the Applicants submit a full translation of the cited reference with the response to the Office Action. Applicants respectfully traverse this rejection.

As required, Applicants have submitted herewith a full translation of the cited document. As noted therein, the cited reference is directed to a core-sheath fiber wherein the core component A is composed of an aromatic polyester which is able to form an anisotropic molten phase. The core-sheath fiber includes a sheath component B which can include a branched poly(arylene sulfide). Examples of the "molten anisotropic polymers" that must be used in the core-sheath fiber can be found on pages 3 and 4 of the English translation submitted herewith. Each example of the combination of monomers that can be used as the core component A includes at least one monomer that can be viewed as completely aromatic, meaning the monomer contains no aliphatic chains. In fact, the cited reference suggests that preferred core component A polymers have the repeating unit shown at the bottom of page 4 and indicates that such "all-aromatic polyesters" are preferred.

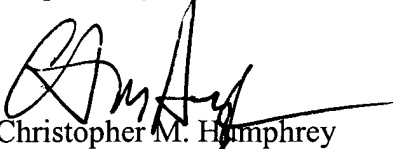
Polyesters of the type described in the cited reference as exemplary polymers for use in core component A are known in the art as liquid crystalline polymers. One of ordinary skill in the art would view the Japanese reference as suggesting that the core component of the fiber taught therein must contain a liquid crystalline polymer that is capable of forming a molten anisotropic phase (i.e., a liquid crystalline phase). As noted above, Claim 1 has been amended to clarify that the component of the claimed fiber that is free of polyarylene sulfide polymer is also free of liquid crystalline polymer. As indicated on page 10, the present invention is not directed to a fiber exhibiting liquid crystalline polymer properties. Since the cited reference clearly requires a core component that includes an aromatic polyester liquid crystalline polymer, it is respectfully submitted that amended Claim 1, and all claims depended thereon, are clearly distinguishable from the teachings of the cited reference.

Applicants also note that PET is not viewed in the art as a liquid crystalline polymer and would not be viewed as a polymer that exhibits an “anisotropic molten phase” as required by the cited reference. This is consistent with the teachings of the cited reference, which on page 5 (paragraph 11), refers to PET as an exemplary “other thermoplastic polymer” that can be added to the molten anisotropic polymer A of the core component. The clear implication of this section is that PET and the other listed polymers (i.e., polyolefins, polycarbonates, polyallylates, polyphenylene sulfide, polyether ester ketones and fluororesins) are not viewed in the art as liquid crystalline polymers. In light of the foregoing, Applicants respectfully request reconsideration and withdrawal of the rejection.

It is not believed that extensions of time or fees for net addition of claims are required, beyond those that may otherwise be provided for in documents accompanying this paper. However, in the event that additional extensions of time are necessary to allow consideration of this paper, such extensions are hereby petitioned under 37 CFR § 1.136(a), and any fee required therefore (including fees for net addition of claims) is hereby authorized to be charged to Deposit Account No. 16-0605.

Appl. No.: 10/728,071
Amdt. dated 02/18/2005
Reply to Office action of October 18, 2005

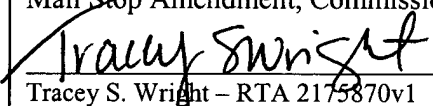
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Tracey S. Wright – RTA 2175870v1



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(43) Kokai Publication Date: May 6, 1994

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Examination request: Not filed Number of claims: 1 (total 7 pages [original])

(21) Application No. Hei 4-274346	(71) Applicant: 000001085 Kuraray Co., Ltd. No. 1621 Sakazu, Kurashiki-shi, Okayama-ken
(22) Filing Date: October 13, 1992	(72) Inventor: NAKAGAWA, Junyou c/o Kuraray Co., Ltd. No. 1621 Sakazu, Kurashiki-shi, Okayama-ken

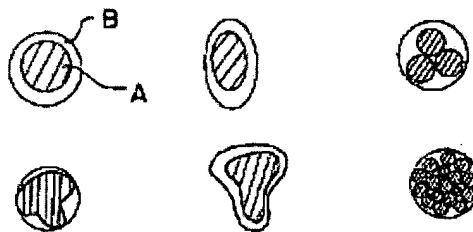
(54) (Title of the Invention) High-Strength, High-Modulus Fiber Having Improved Fatigue Resistance

constituent $R = B/(A+B)$ is 0.05 to 0.6.

(57) (Abstract)

(Purpose) To provide a high-strength, high-modulus fiber having improved fibrillation resistance.

(Constitution) A core-sheath compound fiber wherein a core component A is composed of an aromatic polyester which is able to form an anisotropic molten phase, and the sheath component B is composed of a resin which is a branched poly(arylene sulfide), and the surface area ratio of the B



(Claims)

(Claim 1) A core-sheath compound fiber wherein a core component A is composed of an aromatic polyester which is able to form an anisotropic molten phase, the sheath component B is composed of a resin at least 80 wt % of which is a branched poly(arylene sulfide), and the surface area ratio of the B constituent $R = B/(A+B)$ is 0.05 to 0.6.

(0001)

(Industrial Field of Application) The present invention offers a high-strength, high-modulus fiber having excellent chemical resistance and abrasion resistance. It can be used in a wide range of fields, including general industrial materials, in particular, chemical-resistant rope, clothing, bag filters, and the like, FRC applications, printed circuit ground fabric, screen gauze and similar applications.

(0002)

(Prior Art) Aromatic polyester fibers which form an anisotropic molten phase, as shown in Japanese Laid-Open Patent Application [Kokai] Sho 61-174408, are known as achieving a high strength and high elastic modulus. In these fibers, since the molecular chains are oriented to a large extent in the fiber axial direction, fibrils are created in the fiber axial direction, forming a fiber having high strength and high elastic modulus, merely by a weak intermolecular force acting in a direction perpendicular to the fiber axis, fibrillation can easily occur due to abrasion, becoming the cause of serious trouble. The fiber is also subject to hydrolysis by alkalis and other substances, which results in a deterioration of the physical properties. In order to solve these problems, a composite fiber composed of a core constituent, which is made up of an aromatic polyester formed by an anisotropic molten phase, and a sheath constituent, which is made up of polyphenylene sulfide (PPS), has been proposed by the present inventors in Japanese Kokai No. Hei 1-229815.

(0003)

(Problems the Invention Is to Solve) As is specified in Japanese Kokai No. Hei 1-229815, by making the sheath portion PPS, fibrillation resistance and abrasion resistance can be improved, but since the PPS of the sheath portion is not drawn, it remains in a non-crystallized form, and for this reason, when the fiber is allowed to stand for long periods of time or exposed to high-temperature environments, problems occur such as crystallization, cracking and sheath separation. Since this sheath portion does not contribute to strength or elastic modulus

whatsoever, the greater the ratio of the sheath portion becomes, the more the strength and modulus decrease. Moreover, since the softening point of the core constituent in a non-crystallized state is low, agglomeration between yarns can occur, preventing the heat treatment conditions sufficient for strength enhancement from being used. The inventors, as a result of intensive research, have been able to provide a high-strength, high-modulus fiber with dramatically improved fatigue resistance and no occurrence of surface fibrillation.

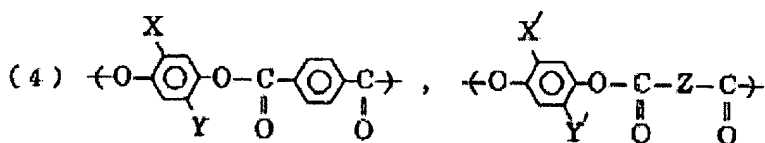
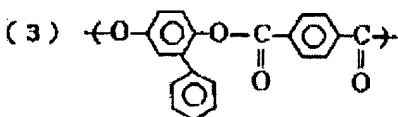
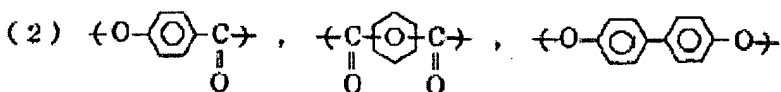
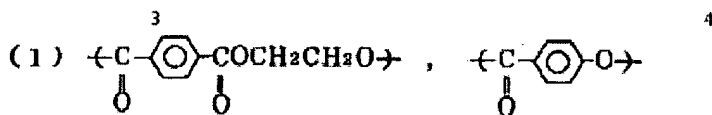
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
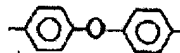



(Means Used to Solve the Problems) The present invention offers a core-sheath compound fiber wherein a core component A is composed of an aromatic polyester which is able to form an anisotropic molten phase, the sheath component B is composed of a resin at least 80 wt % of which is a branched poly(arylene sulfide), and the surface area ratio of the B constituent $R = B/(A+B)$ is 0.05 to 0.6.

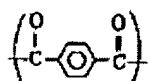
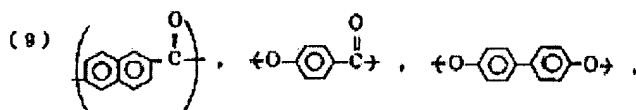
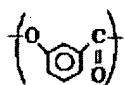
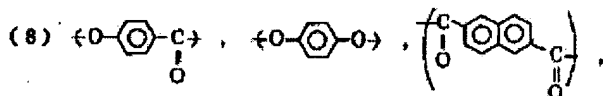
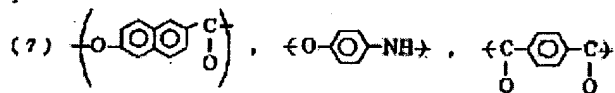
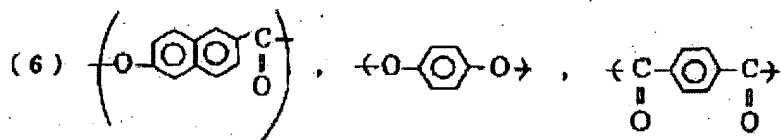
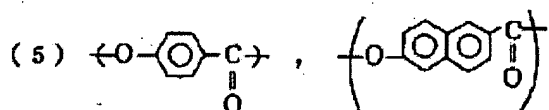
(0005) Examples of the molten anisotropic polymers which can be used in the present invention include polymers formed by combinations of the following repeating constituent units.

(0006)

(Chem 1)



(where X, X', Y, and Y' are each H, Cl, Br or CH₃, and Z is , , ,  or )

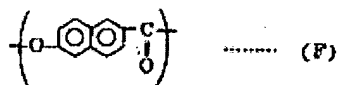
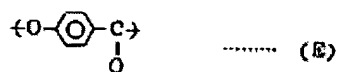


(0007) Desirable molten anisotropic polymers have a melting point MP in a range of 260 to 360°C. Measurement of the MP is performed at the peak temperatures of the main endothermic peaks observed by differential scanning calorimeter (DSC, manufactured by Metra Corp.). Preferably, the MP should be in a range of 270 to 320°C.

(0008) It is optimal for the molten anisotropic polymer used in the present invention to be a polymer composed of repeating constituent units represented by the formulas of Chem 2 below:

(0009)

(Chem 2)



(0010) In particular, all-aromatic polyesters in which the repeating constituent units of (E) and (F) above make up 80 mol % of the total are desirable. Among these, all-aromatic polyesters in which the repeating constituent units of (F) constitute 3 to 45% of the total amount of (E) and (F)

above makes up 80 mol % of the total are especially desirable. The term "molten anisotropy" as used in the present invention means optical anisotropy in the molten phase, which can be confirmed, for example, by placing a sample on a hot stage, raising the temperature in a nitrogen atmosphere, and observing light passing through the sample.

(0011) Other thermoplastic polymers such as polyethylene terephthalate, polyolefins, polycarbonates, polyallylates, polyphenylene sulfide, polyether ester ketones and fluororesins may be added to the molten anisotropic polymer A used in this invention to the extent whereby the effects of the present invention are not lost. Inorganic substances such as titanium oxide, kaolin, silica and barium oxide, carbon black, dyes, pigments, and other colorants, antioxidants, ultraviolet absorption agents, stabilizers and other additives may also be contained within a range of 10 wt %.

(0012) The sheath constituent B of the present invention is a resin at least 80 wt % of which is a branched poly(arylene sulfide); in the term "branched poly(arylene sulfide)" in the present invention, the aromatic units shown in Chem 3 below take up about 80 to 99.9 mol % based on the standard of the total molar quantity.

(0013)

(Chem 3)



(0014) As the method for producing poly(arylene sulfide), industrially, first by reacting a p-dihalobenzene, represented by p-dichlorobenzene, with sodium sulfide, the halogen elements are removed in the form of a sodium halide, then, using the method for manufacturing a polymer such as that shown in Chem 3 above, a polyhalo-aromatic compound having substitution groups for more than 2 of the halogen atoms within a molecule is added in the amount of 0.1 to 5 mol % of the p-dihalobenzene during polymerization.

(0015) The polyhalo-aromatic compound having substitution groups for more than 2 of the halogen atoms within a molecule can be expressed by the formula RX_n , where X is selected from a group consisting of chlorine, bromine and iodine, n is an integer from 3 to 6 and R is a polyvalent aromatic group having the atomic value n, and which can obtain up to about 4 alkyl substitution groups, and the total number of carbon atoms in R is within a range of 6 to 16. Examples of the several polyhalo-aromatic compounds having substitution groups for more than

2 of the halogen atoms within a molecule that can be used in the present invention include 1,2,3-trichlorobenzene, 1,2,4-trichlorobenzene, 1,3-dichloro-5-bromobenzene, 1,2,4-diiodobenzene, 1,2,3,5-tetrabromobenzene, hexachlorobenzene, 1,3,5-trichloro-2,4,6-trimethylbenzene, 2,2',4,4'-tetrachlorobiphenyl, 2,2',5,5'-tetraiodobiphenyl, 2,2',6,6'-tetrabromo-3,3',5,5'-tetramethylbiphenyl, 1,2,3,4-tetrachloronaphthalene, 1,2,4-tribromo-6-methylnaphthalene, similar compounds, and blends thereof. Examples of other compounds which may be included in the sheath component B include the reaction products of p-dihalobenzenes, alkali metal sulfides and organic amides, other polymers in amounts less than 20 wt %, and other additives such as pigments, carbon, heat stabilizers, ultraviolet absorption agents, lubricants, fluorescent whiteners, and the like.

(0016) Since the sheath component in the present invention has a branched structure and, assumes a crosslinked structure by means of spinning and subsequent heat treatment processing, it has a good sheath covering film strength and hardly ever suffers problems such as separation of the sheath component due to abrasion or other factors. Moreover, since there is little agglomeration during heat treatment due to the crosslinked structure, the heat treatment (solid-phase polymerization) of the molten crystal polymer which is the core component can be intensified, forming a fiber having a high strength and high elastic modulus.

(0017) The core-sheath fiber of the present invention can be obtained by conventional methods, for example, using the nozzle structure shown in Fig. 1. Examples of the cross-sectional forms of fibers obtained include those shown in Fig. 2. In the drawings, A is the core component polymer and B is the sheath component polymer. In order to enhance further the effect of the present invention, the composite ratio is made 0.05 to 0.6. The "composite ratio" (R) as used in the present invention is the ratio $R = B/(A+B)$, where A is the sectional area of the core component and B is the sectional area of the sheath component. These sectional areas can be calculated based on microphotographs of the cross-sectional face of the fiber, and obtained by adjusting the discharge amounts of the core and sheath components during manufacture.

(0018) If the composite ratio is less than 0.05, then the covering by the sheath portion is insufficient, a portion of the core is exposed, and separation may occur as a result of friction or abrasion. Contrariwise, if the ratio exceeds 0.6, the core component is reduced and as a result a fiber having low elastic modulus and strength is obtained. The core component in the fibers of the present invention need not be completely coated by the sheath component.

(0019) The composite fiber has sufficient strength and elastic modulus merely by spinning, but these properties can be further enhanced by slack heat treatment and/or tensile heat treatment. Heat treatment can be carried out in an atmosphere of inert gas such as nitrogen or under reduced pressure. It is desirable for the heat treatment atmosphere to have a dewpoint of no higher than -40°C . A pattern whereby heat treatment is performed by gradually raising the temperature from which is under the melting point of the sheath component and the melting point of the core component minus 40°C , can be cited as a heat treatment condition. The treatment time can be from several minutes to several hours, depending on the desired characteristics.

(0020) Heating may be provided by a method using a medium such as air, a method whereby heat is radiated using a device such as a heating plate or infrared heater, a contact method using a heating roller or plate, or an internal heating method using high-frequency waves, etc. This treatment may be performed under tension or in the absence of tension, depending on the objectives. The form of the treatment may be using a the form of a skein, cheese or tow (for example, placement on a metallic net), or by continuous treatment between rollers. The form of the fiber may be filaments or cut fibers. Tensile heat treatment is preferably performed at a temperature 60°C lower than the melting point of the core component, by applying a tension of 10 to 50% of the breaking strength of the fibers. By this means, the elastic modulus and fatigue resistance can be further improved.

(0021) Examples of various industrial applications using fibers obtained by the present invention are discussed hereinunder.

1. Uses in fiber reinforcement (compounding with carbon and glass fibers)

Primary and secondary materials in skis, golf club and gate ball heads and shafts, tennis and badminton racket frames, helmets, pads, frames for glasses, printed circuit boards, motor rotor slots, insulating materials, pipes, high-pressure containers, automobiles, motorbikes, bicycles, trains, ships, aircraft, space vehicles, and the like.

2. Uses in rubber reinforcement

Rubber reinforcing materials for tires, belts, various types of timing belts, and hoses

3. Uses in pipes

1) Abrasion materials (used in blending with other fibers, reinforcement of resins), brake lining, clutch lining, bearings

2) Other

Packing materials, gaskets, filtration materials, polishing materials

4. Uses in the form of cut fibers or chopped fibers

Paper (insulating paper, heat-resistant paper), oscillating materials for speakers, cement reinforcement materials, resin reinforcement materials

5. Control cables, heater line core filaments, tension members (optical fibers, headphone chords, etc.), ropes, cords, climbing ropes, lifelines, fishing lines, nets when used in the form of filaments or spun yarns

6. Uses in the form of a weave or knit

Screen gauze, conveyor belts, sails, tennis, tents, filter cloth, films, bullet-proof vests, safety gloves, safety nets, heat-resistant and flame-resistant clothing, aprons and other protective items, rubber reinforcement cloth, automobiles, trains, ships, aircraft, space vehicles and the like.

As weaves, the fibers of the present invention can be cross woven with other fibers, for example, a base cloth formed of thin metallic threads (10-100 μm) as the warp and fibers of the present invention (10-100 μm) as the weft can be used as a material for electrical products (printed circuit boards, various types of connectors, and the like).

(0022) The term "fibrillation" as used in the present invention refers to the amount of fibrils adhering to a three-point titanium guide when the yarn is passed through the aforementioned guide under a tension of 100 g for 1 hr at a speed of 100 m/min, and is rated as X when the amount of agglomeration is excessive, Δ when the amount is moderate, and O when there is no agglomeration whatsoever. The fatigue resistance strength maintenance ratio referred to in the present invention is rated as the strength maintenance ratio after processing 250,000 times by belt bending test whereby a yarn of approximately 1500 dr (3 strands \times 500 dr) is made into a two-ply yarn having a lower twist of 280 T/m and upper twist of 280 T/m, formed into a cord and embedded in rubber.

(0023) The term "abrasion properties" as used in the present invention was evaluated by the following two methods: 10 strands of test yarn are arranged and twisted together 1.5 times by reverse rotator and sheave on the opposite end, set in a figure-8 form, and a 3 kg weight placed on the sheave. The reverse rotator is then made to twist the yarn together by reciprocating motion, and the inter-fiber abrasion is calculated by the number of times the yarn is twisted together until the yarn breaks. The second test is a grinder abrasion test indicating the number of rotations of a round grinder (rotational speed: 100 rpm, contact angle: 100 degrees) until the yarn

is cut at a load of 1/10g/d.

(0024)

(Embodiments) The present invention is explained below in further detail referring to the embodiments, but the present invention is not limited to these embodiments.

Embodiment 1

An all-aromatic polyester polymer containing the aforesaid constituent units (E) and (F) the ratio of 73/27 wt % was used as the core constituent A.

The physical properties of this polymer were as follows:

MP = 281°C, MV = 500 poise

$\eta_{inh} = 5.0$ dl/g

The melting point MP is the endothermic peak temperature obtained using TA-3000DSC manufactured by Metra Corp. The molten viscosity MV is the value obtained at a shear speed $\gamma = 1000/1$ sec and a temperature of 300°C using a Cappilograph Model B (manufactured by Toyo Seiki Ltd.). 0.1 wt % of sample is dissolved in pentafluorophenol (60-80°C), and measured at 60°C using an Ubbelohde capillary viscosimeter (see, for example, Kobunshi Gakkai, ed., "High molecular science testing methods," Tokyo Kagaku Dojin, p. 179 (1986), Tokyo).

$\eta_{inh} = [\ln(\eta_{rel})]/C$

As the sheath component B, poly(p-phenylene sulfide) to which 0.15 mol % 1,2,4-trichlorobenzene had been added was used.

(0025) Compound spinning at a temperature of 315°C from a 50-hole spinneret shown in Fig. 1 was undertaken at compound ratio $R = 0.33$. The nozzle diameter was 0.15 mm, the winding speed 1000 m/min, and 250 denier filament was obtained. The fiber properties of this filament were:

Strength (DT): 9.1 g/d

Elongation (DE): 2.1%

Modulus of elasticity (IM): 501 g/d

Cross-sectional surface area ratio (R): 0.33

Knot tenacity (KT): 4.2 g/d

Loop tenacity (LT): 6.8 g/d

This fiber was heat-treated for 2 hrs at 240°C and 15 hrs at 277°C in N₂ gas.

(0026) The heat-treated thread the obtained did not have any agglomeration between filaments,

and had the following physical properties:

DT = 24.2 g/d

DE = 3.8%

IM = 532 g/d

KT = 10.3 g/d

LT = 14.8 g/d.

(0027) Comparative Example 1

Other than the fact that poly(p-phenyl sulfide) not containing any branching structure was used as the sheath component, a 250 denier filament was obtained by the same method is used in the Embodiment 1. The physical properties of the fiber obtained were as follows:

DT = 8.7 g/d

DE = 2.0%

IM = 477 g/d

R = 0.33

KT = 3.8 g/d

LT = 5.9 g/d.

Although this filament was treated under the same conditions as that of Embodiment 1, yarn agglomeration was severe, and untangling was not possible. Therefore, the fiber was heat treated for 1 hr at 240°C, 2 hrs at 260°C and 15 hrs at 265°C in N₂ gas. There was no yarn agglomeration, and the filaments were similar to those of Embodiment 1. The physical properties of the fiber obtained were as follows:

DT = 18.2 g/d

DE = 3.0%

IM = 497 g/d

KT = 7.7 g/d

LT = 10.3 g/d.

The fibrillation resistance, fatigue resistance, inter-fiber abrasion and grinder abrasion evaluation results are shown in Table 1.

(0028)

(Table 1)

Example	TD	IM	Fibrillation	Fatigue	Inter-fiber	Grinder
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	(g/d)	(g/d)	resistance	resistance maintenance ratio (%)	abrasion (cycles)	abrasion (cycles)
Embodiment 1	24.2	532	O	92	47,300	5400
Comparative Example 1	18.2	497	Δ	68	30,100	2100

(0029) The fiber of the present invention not only has high strength and high elastic modulus, but also has superior properties with respect to fibrillation resistance, fatigue resistance, inter-fiber abrasion and grinder resistance.

(0030)

(Effects of the Invention) The court-sheath composite fiber of the present invention offers high strength and high elastic modulus, excellent fibrillation resistance and fatigue resistance, with little splitting or separation of core and sheath components even after the passage of long intervals or after being exposed to a high-temperature atmosphere for long periods and has hardly any inter-fiber agglomeration when subjected to heat treatment in order to improve fiber strength.

(Brief Explanation of the Drawings)

Fig. 1 is a cross-sectional diagram showing a nozzle used for manufacturing the fiber of the present invention.

Fig. 2 shows cross-sectional forms of yarn according to the present invention.

(Explanation of the Reference Numerals)

A: core-component polymer

B: sheath-component polymer

Fig. 1

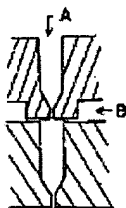


Fig. 2

